BMS INSTITUTE OF TECHNOLOGY AND MANAGEMENT

(Autonomous Institute affiliated to VTU)

Scheme of Teaching and Examination: Effective from AY 2021–22

Choice Based Credit System (CBCS)

UG PROGRAM: Department of Electrical and Electronics Engineering (EEE) — **Semester: VI**

Sl. No	Course Category	CourseCode	Course Title	Teaching Dept.	Teaching Hours /Week				Credits	Examination			
					L	T	P	PW		Duration in Hours	CIE Marks	SEE Marks	Total Marks
1	HS	21HSS61	Project and Finance Management	EE	2	0	0	0	2	2	50	50	100
2	AEC	21AEC62	Bio Informatics	EE	1	0	0	0	1	1	50	50	100
3	AEC	21EE63	Introduction to Standards in Electrical Engineering	EE	1	0	0	0	1	1	50	50	100
4	PE	21EE64X	Professional Elective II	EE	3	0	0	0	3	3	50	50	100
5	OE	21EE65X	Open Elective I	EE	3	0	0	0	3	3	50	50	100
6	PW	21EE66	Mini Project	EE	0	0	0	4	2	3	50	50	100
7	PC	21EE67	Control Systems	EE	4	0	0	0	4	3	50	50	100
8	PC	21EE68	Power System Analysis	EE	3	0	0	0	3	3	50	50	100
9	PC	21EE6L9A	Control Systems Laboratory	EE	0	0	3	0	1	3	50	50	100
10	PC	21EEL69B	Computer aided Electrical Drawing Laboratory	EE	0	1	2	0	1	3	50	50	100
TOTAL					17	1	5	4	**21**		**500**	**500**	**1000**

Professional Elective - Group II	
Course Code	**Course Title**
21EE641	Electrical Design, Estimation and Costing
21EE642	High Voltage Engineering
21EE643	Power System Protection
21EE644	Signals and Systems
21EE645	Batteries and Fuel Cells

Open Elective (OE) - Group I	
CourseCode	**Course Title**
21EE651	Renewable Energy Systems
21EE652	Energy Auditing
21EE653	Electrical Measuring Instruments
21EE654	Electrical Vehicle Technology

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SEMESTER - VI

PROJECT & FINANCE MANAGEMENT (2:0:0) 2

(Effective from the academic year 2020-21)

Course Code	21HSS61	CIE Marks	50
Teaching Hours/Week (L: T:P)	2:0:0	SEE Marks	50
Total Number of Contact Hours	25	Exam Hours	01

Course Objectives:

This course will enable students to:

1. Define the fundamentals of Project Management.
2. Identify the strategies involved in selection, prioritization, planning & scheduling of a project.
3. Understand the time value of money & apply it for decision making.
4. Analyse project risk, progress & results.
5. Make awareness about various sources of finance.
6. Gain Knowledge on working capital & capital budgeting.

Module – 1

Preamble: Project Management: Need for project management, management practices to meet the challenges of new economic environment, globalization process, rapid technological advancement, and quality concerns of the stakeholders.

Project Management: Definition of project, characteristics of projects, types of projects, project roles.

Project Selection & Prioritization: Strategic planning process, strategic objectives, identifying potential projects, feasibility study (environment, society), methods of selecting projects, prioritizing projects, securing and negotiating projects.

Number of Hours: 05

Module – 2

Project planning & scheduling: Project scope & check list, work break down structure, project schedule, uncertainty in project schedules.

Project resourcing & risk planning: Abilities needed when resourcing projects, estimate resource needs, cost planning & estimating, risk management planning, risk identification, risk analysis, project quality planning and project kick-off.

Number of Hours: 05

Module – 3

Project performing, progress & results: Project supply chain management, project balanced score card approach, terminate project early, finish project, customer feedback & approval.

Number of Hours: 05

Module – 4

Financial Management: Evolution of financial management, key activities of finance manager, key decision areas in financial management, financial statement with balance sheet. Efficient utilization and generation of monetary resources and funds, a comparative study of finance and economics, Costs and revenue evaluation for various engineering operations.

Capital Budgeting: Types of capital budgeting decisions, capital budgeting proposals, estimating cash flows for project appraisal, green capital budgeting.

Number of Hours: 05

Module – 5	
Working capital management: Factors affecting working capital requirement, operating cycle analysis, negative working capital, cash planning & managing cash flows. **Cost of capital and leverage Analysis**: Concept, significance, assumptions, factors affecting cost of capital, Leverage Analysis: operating leverage, financial leverage. **Recap:** All the 5 modules. **Number of Hours: 05**	
Course outcomes: The students will be able to: CO1: Understand the selection, prioritization & initiation of individual projects. CO2: Understand WBS, scheduling, uncertainty & risks associated in project. CO3: Identify & Evaluate the progress and results of the project. CO4: Understand time value of money & use it for decision making. CO5: Outline capital requirements for starting a business & management of working capital.	
Textbooks	
1.	Timothy J Kloppenborg, Project Management, Cengage Learning, 2nd Edition, 2009.
2.	John J Hampton, Financial Management, PHI Publication, 4th edition.
References	
1.	Pennington Lawrence, Project Management, McGraw-Hill, 1st edition.
2.	Joseph A Moder, Philips New Yark, Project Management with CPM & PRT, McGraw-Hill, 2nd edition, 1983.
3.	Harold Kerzner, Project Management A system approach to Planning, Scheduling & Controlling, CBS Publication, 2nd Edition,2006.
4.	S.D. Sharma, Operations Research, Kedar Nath Ramnath, Meerut, New Edition,2015.
5	M.Y. Khan, Financial Management, Tata Mc-Graw Hill, Fifth Edition,2007.
6	O.P. Khanna, Industrial Engineering & Management, Dhanpat Rai Publications, Second Edition, 1999.

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SEMESTER - VI

Bioinformatics (1:0:0) 1

(Effective from the academic year 2023-24)

Course Code	21AEC62	CIE Marks	50
Teaching Hours/Week (L:T:P)	1:0:0	SEE Marks	50
Total Number of Contact Hours	15	Exam. Hours	3

Course Objectives:

1. Better understanding of dynamic biological processes and their understanding at molecular level enabled through and correlated using internet and Bioinformatics.
2. To relate the basic knowledge in Genetics & Molecular Biology and see how it can be applied through Bioinformatics perspective.
3. To utilize bioinformatics tools and databases for retrieving, analyzing, understanding and managing biological data.

Module – 1

Preamble: Bioinformatics is an interdisciplinary field mainly involving molecular biology and genetics, computer science, mathematics, and statistics. Data intensive, large-scale biological problems are addressed from a computational point of view.

Biological Data Acquisition

The form of biological information. Retrieval methods for DNA sequence, protein sequence and protein structure information

(3 Hours)

Module – 2

DATABASES

Format and Annotation: Conventions for database indexing and specification of search terms, Common sequence file formats. Annotated sequence databases – primary sequence databases, protein sequence and structure databases, Organism specific databases.

(3 Hours)

Module – 3

DATA PROCESSING

Data – Access, Retrieval and Submission: Standard search engines; Data retrieval tools – Entrez, DBGET and SRS; Submission of (new and revised) data; Sequence Similarity Searches: Local versus global. Distance metrics. Similarity and homology. Scoring matrices.

(3 Hours)

Module – 4

METHODS OF ANALYSIS

Dynamic programming algorithms, Needleman-wunsch and Smith-waterman. Heuristic Methods of sequence alignment, FASTA, and PSI BLAST.

(3 Hours)

Module – 5

APPLICATIONS

Genome Annotation and Gene Prediction; ORF finding; Phylogenetic Analysis: Comparative genomics, orthologs, paralogs.

(3 Hours)

Course Outcomes: The students will be able to:

CO1: Apply the basic methodology in Bioinformatics to retrieve data.
CO2: Analyse bioinformatics tools and databases for understanding and managing biological data.
CO3: Examine the applications of bioinformatics in allied areas.

ASSESSMENT METHODS

CIE Components (50 Marks)
Three Internal Assessments Tests (MCQ based) each of 40 Marks (duration 01 hour)
Two Assignment: 20 Marks
Two AATs: 20 Marks
Sum of the Assignment and AATs will be out of 40 Marks and scaled down to 20 Marks.

Sum of the three Internal Assessments Tests Marks will be out of 120 Marks and scaled down to 30 Marks.

Internal Assessments from Tests: 30 Marks
Assignment and AAT: 20 Marks
Total CIE Marks: 50 Marks

Semester-End Examination (50 Marks)

- SEE question paper will be set for 50 questions of each of 01 mark.
- The pattern of the question paper is MCQ.

Assessment Details (both CIE and SEE):

- The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%.
- The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50).
- The minimum passing mark for the SEE is 35% of the maximum marks (18 marks out of 50).

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50) in the semester-end examination (SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Textbooks:

1. Introduction to Bioinformatics by Arthur K. Lesk , Oxford University Press.
2. Algorithms on Strings, Trees and Sequences by Dan Gusfield, Cambridge University Press.
3. Biological Sequence Analysis Probabilistic Models of proteins and nucleic acids by Durbin, S.Eddy, A.Krogh, G.Mitchison.
4. Bioinformatics Sequence and Genome Analysis by David W. Mount, Cold Spring Harbor Laboratory Press.
5. Beginning Perl for Bioinformatics: An introduction to Perl for Biologists by James Tindall, O"Reilley Media.

References:

1. Bioinformatics The Machine Learning Approach by Pierre Baldi and Soren Brunak.

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SEMESTER – VI

Introduction to Standards in Electrical Engineering (1:0:0) 1

(Effective from the academic year 2021-22)

Course Code	21EE63	CIE Marks	50
Teaching Hours/Week (L:T:P)	1:0:0	SEE Marks	50
Total Number of Contact Hours	15	Exam Hours	02

Course Objectives:

This course will enable students to:

1. Appreciate the necessity of standards in the engineering
2. Understand the evolution of standards in electrical engineering
3. Understand the certification of products and systems

Module – 1

Nearly every aspect of our life is framed, guided, and normalised by standards and their evolution. Standardisation encourages optimal business practises that prioritise quality assurance and safety in industries including accounting, healthcare, and agriculture. Standards serve as a reflection of the common goals, aspirations, and obligations that our society projects onto one another and the environment. Following the most recent standards can encourage innovation, boost the market value of an engineer's research and design efforts, and encourage global trade and commerce, which in turn stimulates more innovation.

Necessity of Standards, International Standardisation Organisation (ISO), Origin of Bureau of Indian Standards, Technical Departments, Product Certification, Systems Certifications, Hallmarking

(07 Hours)

Module – 2

Five Principles of BIS: Safety, Ease of use and adaptability, Simple technology, Value for money products, Energy efficiency and environment. National Electrical Code of India (NEC), Code of Practice for Electrical Wiring Installation, Earthing, Batteries, Cables, Standards for Emerging Areas

(08 Hours)

Course Outcomes:

CO1: Appreciate the necessity of standards in the engineering
CO2: Understand the evolution of standards in electrical engineering
CO3: Understand the certification of products and systems

ASSESSMENT METHODS

CIE Components (50 Marks)

Three Unit Tests each of 40 Marks (duration 01 hour)
Two Assignment: 20 Marks
Two AATs: 20 Marks

Sum of the Assignment and AATs will be out of 40 Marks and scaled down to 20 Marks
Sum of the three Internal Assessments Tests Marks will be out of 120 Marks and scaled down to 30 Marks i.e.

Internal Assessments Tests: 30 Marks
Assignment and AAT: 20 Marks
Total CIE Marks: 50 Marks

Semester-End Examination (50 Marks)

- SEE question paper will be set for 50 questions of each of 01 marks
- The pattern of the question paper is MCQ.

Assessment Details (both CIE and SEE):

- The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%.
- The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50).
- The minimum passing mark for the SEE is 35% of the maximum marks (18 marks out of 50).

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50) in the semester-end examination (SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Textbooks

1. Resource materials from 'Indian Bureau of Standards' website.

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SEMESTER - VI

ELECTRICAL DESIGN, ESTIMATION AND COSTING (3:0:0) 3

(Professional Elective Group – II)

(Effective from academic year 2021 -2022)

Course Code	21EE641	CIE Marks	50
Teaching Hours/Week (L: T:P)	3:0:0	SEE Marks	50
Total Number of Lecture Hours	40	Exam Hours	3

Course objectives:

This course will enable students to:

1. Discuss market survey, estimates, purchase enquiries, preparation of tenders, comparative statements and payment of bills and Discuss Indian Electricity act and Indian Electricity rules
2. Discuss distribution of energy in a building, wiring and methods of wiring, cables used in internal wiring, wiring accessories and fittings, fuses and types of fuses.
3. Discuss design of lighting points and its number, total load, sub-circuits, size of conductor and types of service mains and estimation of service mains and power circuits.
4. Discuss estimation of overhead transmission and distribution system and its components.
5. Discuss main components of a substation, preparation of single line diagram of a substation and earthing of a substation.

Module – 1

Principles of Estimation: Introduction to Estimation and Costing, Electrical Schedule, Catalogues, Market Survey and Source Selection, Recording of Estimates, Determination of Required Quantity of Material, Labour Conditions, Determination of Cost Material and Labour, Contingencies, Overhead Charges, Profit, Purchase System, Purchase Enquiry and Selection of Appropriate Purchase Mode, Comparative Statement, Purchase Orders, Payment Of Bills, Tender Form, General Idea about IE Rule, Indian Electricity(IE) Act and IE Rules - 29,30,45,46,47,50,51,54,55,77 and79.

(8 Hours)

Module – 2

Wiring: Introduction, Distribution of energy in a Building, PVC Casing and Capping, Conduit Wiring, Desirabilities of Wiring. Types of cables used in Internal Wiring, Multi Strand Cables, Voltage Grading and Specification of Cables
Wiring (continued): Main Switch and Distribution Board, Conduits and its accessories and Fittings. Lighting Accessories and Fittings, Types of Fuses, Size of Fuse, Fuse Units, Earthing Conductor. Internal Wiring: General rules for wiring, Design of Lighting Points (Refer to Seventh Chapter of the Textbook), Number of Points, Determination of Total Load, Number of Sub –Circuits, Ratings Main Switch and Distribution Board and Size of Conductor. Current Density, Layout.

(8 Hours)

Module – 3

Service Mains: Introduction, Types, Estimation of Underground and Overhead Service Connections. Design and Estimation of Power Circuits: Introduction, Important Considerations Regarding Motor Installation Wiring, Input Power, Input Current to Motors, Rating of Cables, Rating of Fuse, Size of Condit, Distribution Board Main Switch and Starter.

(8 Hours)

Module – 4

Estimation of Overhead Transmission and Distribution Lines: Cross Arms, Pole Brackets and Clamps, Guys and Stays, Conductors Configuration Spacing and Clearances, Span Lengths, Lightning Arrestors, Phase Plates, Danger Plates, Anti Climbing Devices, Bird Guards, Beads of Jumpers, Muffs, Points to be Considered at the Time of Erection of Overhead Lines, Erection of Supports, Setting of Stays, Fixing of Cross Arms, Fixing of Insulators, Conductor Erection.

Estimation of Overhead Transmission and Distribution Lines (continued): Repairing and Jointing of Conductors, Dead End Clamps, Positioning of Conductors and Attachment to Insulators, Jumpers, Tee-Offs, Earthing of Transmission Lines, Guarding of Overhead Lines, Clearances of Conductor from Ground, Spacing Between Conductors, Important Specifications.

(8 Hours)

Module – 5

Estimation of Substations: Main Electrical connection, Graphical Symbols for Various Types of Apparatus and Circuit Elements on Substation main Connection Diagram, Single Line Diagram of Typical Substations, Equipment for Substation, Substation Auxiliaries Supply, Substation Earthing.

(8 Hours)

Course outcomes:

The students will be able to:

CO1. Analyze the general principles, rules and instructions for electrical estimation and costing of various electrical systems

CO2. Analyze the various materials used in electrical installations

CO3. Analyze the general rules for service connection and power wiring circuit and preparing estimation

CO4. Design and prepare estimation and costing for different transmission line installations

CO5. Design and prepare estimation and costing for different substation installations.

Textbooks

1	N. Mohan T.M. Undemand; W.P. Robbins, Power Electronics, Converters, Applications and Design, John Wiley and Sons, 1995
2	Jahangir, Mahmud, Renewable Energy Integration Challenges and Solutions Series reen Energy and Technology Hossain, Apel (Eds.)

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SEMESTER - VI

HIGH VOLTAGE ENGINEERING (3:0:0) 3

(Professional Elective - Group II)

(Effective from the academic year 2020 -2021)

Course Code	21EE642	CIE Marks	50
Teaching Hours/Week (L:T:P)	3	SEE Marks	50
Total Number of Lecture Hours	40	Exam Hours	3

Course objectives:

This course will enable students to:

1. To discuss conduction and breakdown in gases, liquid dielectrics.
2. To discuss breakdown in solid dielectrics.
3. To discuss generation of high voltages and currents and their measurement.
4. To discuss overvoltage phenomenon and insulation coordination in electric power systems
5. To discuss about high voltage testing of electrical apparatus

Module – 1

Conduction and Breakdown in Gases: Gases as Insulating Media, Collision Process, Ionization Processes, Townsend's Current Growth Equation, Current Growth in the Presence of Secondary Processes, Townsend's Criterion for Breakdown, Experimental Determination of Coefficients α and γ, Breakdown in Electronegative Gases, Time Lags for Breakdown, Streamer Theory of Breakdown in Gases, Paschen's Law, Breakdown in Non-Uniform Fields and Corona Discharges.

Conduction and Breakdown in Liquid Dielectrics: Liquids as Insulators, Pure Liquids and Commercial Liquids, Conduction and Breakdown in Pure Liquids, Conduction and Breakdown in Commercial Liquids.

Breakdown in Solid Dielectrics: Introduction, Intrinsic Breakdown, Electromechanical Breakdown, Thermal Breakdown

(8 Hours)

Module – 2

Generation of High Voltages and Currents: Generation of High Direct Current Voltages, Generation of High Alternating Voltages, Generation of Impulse Voltages, Generation of Impulse Currents, Tripping and Control of Impulse Generators.

(8 Hours)

Module – 3

Measurement of High Voltages and Currents: Measurement of High Direct Current Voltages, Measurement of High AC and Impulse Voltages, Measurement of High Currents – Direct, Alternating and Impulse, Cathode Ray Oscillographs for Impulse Voltage and Current Measurements.

(8 Hours)

Module – 4

Overvoltage Phenomenon and Insulation Coordination in Electric Power Systems: National Causes for Over voltages - Lightning Phenomenon, Overvoltage due to Switching Surges, System Faults and Other Abnormal, Principles of Insulation Coordination on High Voltage and Extra High Voltage Power Systems

(8 Hours)

Module – 5

Non-Destructive Testing of Materials and Electrical Apparatus: Introduction, Measurement of Dielectric Constant and Loss Factor, Partial Discharge Measurements.

High Voltage Testing of Electrical Apparatus: Testing of Insulators and Bushings, Testing of Isolators and Circuit Breakers, Testing of Cables, Testing of Transformers.

(8 Hours)

Course outcomes:

The students will be able to:

CO1: Explain conduction and breakdown phenomenon in gases, liquid dielectrics and solid dielectrics.

CO2: Elucidate the concepts used for generation of high voltages and currents and measurement of high voltages and currents.

CO3: Understand the overvoltage phenomenon and insulation coordination in electric power systems.

CO5: Explain non-destructive testing of materials and electric apparatus, high-voltage testing of electric apparatus

Textbooks

1. M.S. Naidu, V.Kamaraju, "High Voltage Engineering", McGraw Hill, 5th Edition, 2013.

References:

1. W E. Kuffel, W. S. Zaengl and J. Kuffel, "High Voltage Engineering – Fundamentals', Newnes ,Second edition, 2000.
2. C. L. Wadhwa, "High Voltage Engineering", New Age International (P) Limited, Publishers, 3rd edition , 2012.
3. Wolfgang Hauschild ,Eberhard Lemke, "High-Voltage Test and Measuring Techniques", Springer, 1st Edition2014.
4. Farouk A.M. Rizk, "High Voltage Engineering", CRC Press, 1st Edition ,2014.
5. Ravindra Arora, Bharat Singh Rajpurohit, "Fundamental of High Voltage Engineering", Wiley, 2019.

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Choice Based Credit System (CBCS)

SEMESTER - VI

Power System Protection (3:0:0)3

(Professional Elective - Group II)

(Effective from the academic year 2021 -2022)

Course Code	21EE643	CIE Marks	50
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	50
Total Number of Contact Hours	40	Exam Hours	3

Course Objectives:

This course will enable students to:

1. Discuss relay construction and operating principles, performance of protective relays, components of protection scheme and relay terminology.
2. Discuss over current protection using electromagnetic and static relays and overcurrent protective schemes.
3. Discuss types of electromagnetic and static distance relays, effect of arc resistance, power swings, line length and source impedance on performance of distance relays.
4. Discuss pilot protection; wire pilot relaying and carrier pilot relaying.
5. Discuss construction, operating principles and performance of various differential relays for differential protection.
6. Discuss protection of generators, motors, Transformer and Bus Zone Protection.
7. Discuss the principle of circuit interruption and different types of circuit breakers.
8. Discuss construction and operating principle of different types of fuses and to give the definitions of different terminologies related to a fuse.
9. Discuss protection Against Over voltages and Gas Insulated Substation (GIS).

Module – 1

Introduction: Importance of Electrical Power System Protection, how the power system Protection plays a role in the economic growth of our country, it's importance in safety of Power System and societal benefits, Relevance of protection in existing national Power Grid.

Switches And Fuses: Introduction and Definitions, Isolating switch, Fuse law, cut-off characteristics and time current characteristics, Fuse material, HRC fuse, Liquid fuse, Application of fuse, Selection of fuses, Discrimination.

Principles of Circuit Breakers: Importance of the circuit breakers in the power system at low cost and high efficiency, Principles of AC circuit breaking, Principles of DC circuit breaking, Arc initiation, maintenance and interruption, Arc interruption theories - Slepian's theory and energy balance theory, Re-striking voltage, Recovery voltage, Rate of rise of re-striking voltage, Current chopping, High Voltage direct current circuit breakers, Rating of circuit breakers, testing of circuit breakers.

(8Hours)

Module – 2

Circuit Breakers: Importance to the circuit breakers in the power system at low cost and high efficiency. Classification of circuit breakers (CB), Air blast circuit breakers, Air break CB, Oil circuit breakers – single break, double break, minimum oil, SF6 breaker -properties of SF6 gas puffer and non-puffer type of SF6 breakers, Vacuum CB, Operating mechanism of CB, Rating CB.

Philosophy of protective relaying system: Need for protective system, Types and effects of faults, Zones of Protection, Primary and Back up Protection, Essential qualities of protective relaying, Classification of protective relays, Classification of protective schemes, CT & PT for Protection.

(8Hours)

Module – 3

Relays: Principle of relay operation, Static relays (block diagrams) – overcurrent, directional, distance relays, Advantages and limitations of static relays, Comparators-duality between amplitude and phase comparators, Rectifier bridge and phase splitting type amplitude comparators, coincidence type phase comparator.

Relay characteristics: Non-directional and Directional overcurrent relays, IDMT and directional characteristics. Differential relay –Types of differential relay, Distance Protection - impedance relay, reactance, Mho relay.

(8Hours)

Module – 4

Protection Schemes: Generator protection scheme - stator & rotor protection. Transformer protection - external and internal faults protection, Buchholz Relay, Bus- zone protection - differential current protection, frame leakage protection of busbar, ring main protection, Motor protection - ground fault and phase fault protection, Pilot relaying schemes - circulating current scheme, balanced voltage scheme, Carrier aided distance protection.

(8 Hours)

Module – 5

Numerical Protection: Numerical over current and distance protection (generalized interface).

Wide area measurement application: Introduction, PMU, WAMS architecture, Adaptive relaying - transformer protection, transmission line protection, reclosing, WAMS based protection concepts - supervision of backup zones, intelligent load shedding, load shedding and restoration.

Summary: The students get exposed to various Protection Schemes in Power System, Switches, Fuses, Circuit Breakers, and Relays.

(8 Hours)

Course Outcomes:

The students will be able to

CO1: Understand the differences between various power system components.

CO2: Apply practical/field & theoretical problems associated with Power System Switchgear & Protection.

CO3: Design suitable switchgear protection schemes for power system protection.

CO4: Analyse the power system protection strategies and interpret system design & performance strategies.

Textbooks:

1. Badri Ram, D.N. Vishwakarma, "Power System Protection and Switchgear", McGraw Hill, 2nd Edition
2. BhuvaneshOza et al, "Power System Protection and Switchgear", (For additional study on gapless arrester, Refer to pages 458 to 461), McGraw Hill, 1st Edition, 2010

References:

1. Bhavesh et al, "Protection and Switchgear", Oxford, 1st Edition, 2011
2. N. Veerappan S.R. Krishnamurthy, "Power System Switchgear and Protection", S. Chand, 1st Edition, 2009
3. Y.G.Paithankar S.R. Bhide, "Fundamentals of Power System Protection", PHI, 1st Edition, 2009

B.E ELECTRICAL AND ELECTRONICS ENGINEERING

Choice Based Credit System (CBCS)

SEMESTER - VI

Signals and Systems (3:0:0) 3

(Professional Elective Group – II)

(Effective from academic year 2021 -2022)

Course Code	21EE644	CIE Marks	50
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	50
Total Number of Contact Hours	40	Exam Hours	3

Course objectives:

This course will enable students to:

1. Discuss the origin of signals in different systems.
2. Classify the signals and define certain elementary signals.
3. Explain basic operations on signals and properties of systems.
4. Explain the use of convolution integral and convolution summation in system analyses
5. Determine the response of linear time invariant systems in continuous and discrete time domains.
6. Explain the properties of linear time invariant systems in terms of impulse response description.
7. Explain determination of response of a given linear time invariant system and to provide a block diagram representation to it.
8. Explain Fourier transform representation of continuous time and discrete time non – periodic signals and the properties of Fourier Transforms.
9. Explain the applications of Fourier transform representation to study signals and linear time invariant systems.
10. Explain the use of Z-transform in the complex exponential representation of discrete time signals and the analysis of systems

Module – 1

Introduction:

Signal processing as an enabling technology, power and promise of Signal processing, Signal processing as a growth skill set.

Definitions of signals and a system, Signals and systems as seen in everyday life, and in various branches of engineering and science, classification of signals, Some special signals of importance: the unit step, the unit impulse, the sinusoid, the complex exponential, basic operations on signals. Elementary signals viewed as interconnections of operations, properties of systems**.** The Sampling Theorem and its implications.

(08 Hours)

Module – 2

Continuous and Discrete Time LTI Systems Analysis: Convolution, impulse response, properties, solution of differential equation, block diagram representation**.**

(08 Hours)

Module – 3

The Continuous-Time Fourier Transform: Representation of non -periodic signals: continuous-time Fourier transform (FT), Properties of continuous-time Fourier transform, and its applications. Solutions of differential equations.

(08 Hours)

Module – 4

The Discrete-Time Fourier Transform: Representations of non-periodic signals: The discrete-time Fourier transform (DTFT), Properties of DTFT and applications. Frequency

response of LTI system, Solutions of differential equations.

(08 Hours)

Module – 5

Z- Transforms: Introduction, Z-transform, properties of ROC, properties of Z-transforms, inversion of Z-transform methods - power series and partial expansion, unilateral Z-transform and its application to solve difference equations.

Summary: Recap of key roles played by signal processing in multiple industries. Highlighting its diversity, relevance, and importance

(08 Hours)

Course outcomes:

The students will be able to

CO1:**Classify** the signals and systems, and perform basic operations on signals

CO2: **Represent** the CT and DT systems in multiple forms

CO3: **Analyse** systems based on given representation in time domain

CO4: **Examine** signals and linear time invariant systems using Transform domain tools

Textbooks:

1. J. G. Proakis and D. G. Manolakis, "Digital Signal Processing: Principles, Algorithms and Applications", Pearson, 3rd Edition, 2006.
2. S. Haykin and B. V. Veen, "Signals and Systems", John Wiley and Sons, 2007.

References:

1. V. Oppenheim and R. W. Schafer, "Discrete-Time Signal Processing", Prentice Hall, 2nd Edition, 2009.
2. M. J. Robert, "Fundamentals of Signals and Systems", McGraw Hill Education, 2007.

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SEMESTER - VI

BATTERIES AND FUEL CELLS (3:0:0)

(Professional Elective - Group II)

(Effective from the academic year 2021 -2022)

Course Code	21EE645	CIE Marks	50
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	50
Total Number of Contact Hours	40	Exam Hours	3

Course objectives:

This course will enable students to:

1. To explain the current status of various primary and secondary (rechargeable) batteries and fuel cells for various applications, their performance capabilities and limitations.
2. To explain the performance requirements for next-generation high-power rechargeable batteries suited for applications requiring high-energy and -power densities, their design configurations for some specific applications with a particular emphasis on safety, reliability, longevity, and portability.
3. To explain fuel cells that are best suited for applications where electrical power requirements vary between several kilowatts (kW) to a few megawatts (MW).
4. To explain high-power batteries currently used by EVs and HEVs and their performance review and rechargeable battery design configurations capable of providing significant improvements in depth of discharge, state of charge, and service life.
5. To explain low-power battery configurations that are best suited for compact commercial, industrial, and medical applications.
6. To describe rechargeable batteries for military and battlefield applications where sustainable performance, reliability, safety, and portability are principal operating requirements.

Module – 1

Current Status of Rechargeable Batteries and Fuel Cells : : Rechargeable Batteries, Fundamental Aspects of a Rechargeable Battery, Rechargeable Batteries Irrespective of Power Capability, Rechargeable Batteries for Commercial and Military Applications, Batteries for Low-Power Applications, Fuel Cells. (8 Hours)

Module – 2

Batteries for Aerospace and Communications Satellites: Introduction, On-board Electrical Power System, Battery Power Requirements and Associated Critical Components, Cost-Effective Design Criterion for Battery-Type Power Systems for Spacecraft, Spacecraft Power System Reliability, Ideal Batteries for Aerospace and Communications Satellites, Performance Capabilities and Battery Power Requirements for the Latest Commercial and Military Satellite Systems, Military Satellites for Communications, Surveillance, Reconnaissance, and Target Tracking, Batteries Best Suited to Power Satellite Communications Satellites. (8 Hours)

Module – 3

Fuel Cell Technology:

Introduction, Performance Capabilities of Fuel Cells Based on Electrolytes, Low-Temperature Fuel Cells Using Various Electrolytes, Fuel Cells Using a Combination of Fuels, Fuel Cell Designs for Multiple Applications, Ion-Exchange Membrane Fuel Cells, Potential Applications of Fuel Cells, Fuel Cells for Aircraft Applications, Fuel Cells for Commercial, Military, and Space Applications, Fuel Cells Capable of Operating in Ultra-High-Temperature Environments, Fuel Cell Requirements for Electric Power Plant Applications. (8 Hours)

Module – 4

Batteries for Electric and Hybrid Vehicles: Introduction, Chronological Development History of Early Electric Vehicles and Their Performance Parameters, Electric and Hybrid Electric Vehicles, Developed Earlier by Various Companies and Their Performance Specifications, Development History of the Latest Electric and Hybrid Electric Vehicle Types and Their Performance Capabilities and Limitations, Performance Requirements of Various Rechargeable Batteries, Materials for Rechargeable Batteries, Critical Role of Rare Earth Materials in the Development of EVs and HEVs.

(8 Hours)

Module – 5

Low-Power Rechargeable Batteries for Commercial, Space, and Medical Applications: Introduction, Low-Power Battery Configurations, Characteristics, Batteries for Miniaturized Electronic System Applications, for Embedded-System Applications, Batteries for Medical Applications, Selection Criteria for Primary and Secondary (Rechargeable) Batteries for Specific Applications. (8 Hours)

Recap/summary of the course.

Course outcomes:

The students will be able to

CO1: Discuss the current status of primary and secondary (rechargeable) batteries and fuel cells for various applications, their performance capabilities and limitations.

CO2: Explain the performance requirements for next-generation high-power rechargeable batteries suited for applications requiring high-energy and -power densities, their design configurations for specific applications with emphasis on safety, reliability, longevity, and portability.

CO3: Explain fuel cells suitable for applications where electrical power requirements vary between several kilowatts (kW) to a few megawatts (MW).

CO4: Explain the working of high-power batteries currently used by EVs and HEVs

CO5: Discuss the design configurations and performance of high-power batteries.

CO6: Explain low-power battery configurations best suited for compact commercial, industrial, and medical applications.

CO7: Describe rechargeable batteries for military and battlefield applications.

Textbooks:

1. Next-Generation Batteries and Fuel Cells for Commercial, Military, and Space Applications, A.R. JHA, CRC Press, 1st Edition, 2012

References:

1. Electrochemical Power Sources: Batteries, Fuel Cells, and Supercapacitors, Vladimir S. Bagotsky, John Wiley, 1st Edition,2015.
2. Modelling and Control of Fuel Cells: Distributed Generation Applications M. HashemNehrir Caisheng Wang, Wiley, 1st Edition,2009.

B.E ELECTRICAL AND ELECTRONICS ENGINEERING

Choice Based Credit System (CBCS)

SEMESTER - VI

RENEWABLE ENERGY SYSTEMS (3:0:0) 3

(Open Elective – Group I)

(Effective from the academic year 2021-22)

Course Code	21EE651	CIE Marks	50
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	50
Total Number of Contact Hours	40	Exam Hours	3

Course Objectives:

1. Awareness about Renewable Energy Sources and technologies.
2. Adequate inputs on a variety of issues in harnessing renewable Energy.
3. Recognize current and possible future role of renewable energy sources.

Module – 1

Introduction: Importance of electric power generation in indian economy, factors influencing power generation, Green energy concepts, Causes of Energy Scarcity, Solution to Energy Scarcity, Factors Affecting Energy Resource Development, Energy Resources and Classification, Renewable Energy – Worldwide Renewable Energy Availability, Renewable Energy in India.

Solar Thermal Energy Collectors: Types of Solar Collectors, Configurations of Certain Practical Solar Thermal Collectors, Material Aspects of Solar Collectors, Concentrating Collectors, Parabolic Dish – Stirling Engine System, Working of Stirling or Brayton Heat Engine, Solar Collector Systems into Building Services, Solar Water Heating Systems, Passive Solar Water Heating Systems, Applications of Solar Water Heating Systems, Active Solar Space Cooling, Solar Air Heating, Solar Dryers, Crop Drying, Space Cooing, Solar Cookers, Solar pond.

(8 Hours)

Module – 2

Solar Cells: Components of Solar Cell System, Elements of Silicon Solar Cell, Solar Cell materials, Practical Solar Cells, I – V Characteristics of Solar Cells, Efficiency of Solar Cells, Photovoltaic panels (series and parallel arrays).

Wind Energy: Windmills, Wind Turbines, Wind Resources, Wind Turbine Site Selection.

(8 Hours)

Module – 3

Hydrogen Energy: Benefits of Hydrogen Energy, Hydrogen Production Technologies, Hydrogen Energy Storage, Use of Hydrogen Energy, Advantages and Disadvantages of Hydrogen Energy, Problems Associated with Hydrogen Energy.

Geothermal Energy: Geothermal Systems, Classifications, Geothermal Resource Utilization, Resource Exploration, Geothermal Based Electric Power Generation, Associated Problems, environmental Effects. (8 Hours)

Module – 4

Biomass Energy: Biomass Production, Energy Plantation, Biomass Gasification, Theory of Gasification, Gasifier and Their Classifications, Updraft, Downdraft and Cross-draft Gasifiers, Fluidized Bed Gasification, Use of Biomass Gasifier, Applications of Biomass Gasifier.

Biogas Energy: Introduction, Biogas and its Composition, Anaerobic Digestion, Biogas Production, Benefits of Biogas, Factors Affecting the Selection of a Particular Model of a Biogas Plant.

Tidal Energy: Introduction, Tidal Energy Resource, Tidal Energy Availability, Energy Availability in Tides, Tidal Power Basin, Turbines for Tidal Power, Advantages and Disadvantages of Tidal Power, Problems Faced in Exploiting Tidal Energy. (8 Hours)

Module – 5

Sea Wave Energy: Introduction, Motion in the sea Waves, Power Associated with Sea Waves, Devices for Harnessing Wave Energy, Advantages and Disadvantages of Wave Power.

Ocean Thermal Energy: Introduction, Principles of Ocean Thermal Energy Conversion (OTEC), Ocean Thermal Energy Conversion plants, Basic Rankine Cycle and its Working, Closed Cycle, Open Cycle and Hybrid Cycle, Carnot Cycle, Application of OTEC in Addition to Produce Electricity, Advantages, Disadvantages and Benefits of OTEC. (8 Hours)

Course Outcomes: At the end of the course the student will be able to

CO1: Discuss causes of energy scarcity and its solution, energy resources and availability of renewable energy.

CO2: Discuss types of solar collectors, their configurations, solar cell system, its characteristics and their applications.

CO3: Explain the operation of various renewable energy systems.

CO4: Explain different emerging energy conversion technologies and storage.

Textbooks:

1. Shobh Nath Singh, "Nonconventional Energy Resources", Pearson, 1st Edition, 2015.

References:

1. Godfrey Boyle, "Renewable Energy: Power for a sustainable Future", Oxford, 3rd Edition, 2012.
2. Tasneem Abbasi, S.A. Abbasi, "Renewable Energy Sources: Their Impact on global Warming and Pollution", PHI 1st Edition, 2011.

B.E ELECTRICAL AND ELECTRONICS ENGINEERING

Choice Based Credit System (CBCS)

SEMESTER - VI

ENERGY AUDITING (3:0:0) 3

(Open Elective – Group I)

(Effective from the academic year 2021-22)

Course Code	21EE652	CIE Marks	50
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	50
Total Number of Contact Hours	40	Exam Hours	3

Course Objectives:

- Awareness about energy audit.
- Description of energy billing, role of power factor and its control
- Performance evaluation of various electrical loads.
- Description various elements and types of energy auditing.
- Description of Framework of Indian power sector and the availability-based tariff.

Module – 1

Energy Scenario: Commercial and Non-commercial energy, primary energy resources, commercial energy production, energy needs of growing economy, long term energy scenario, energy pricing, energy sector reforms, energy and environment, energy security, energy conservation and its importance, restructuring of the energy supply sector, energy strategy for the future, air pollution, climate change. Energy Conservation Act-2001 and its features.

(8 Hours)

Module – 2

Energy Efficiency in Electrical Systems: Electricity billing, Electrical load management and maximum demand Control, Maximum demand controllers; Power factor improvement, Automatic power factor controllers, efficient operation of transformers, energy efficient motors, Soft starters, Variable speed drives; Performance evaluation of fans and pumps, Flow control strategies and energy conservation opportunities in fans and pumps, Electronic ballast, Energy efficient lighting and measures of energy efficiency in lighting system.

(8 Hours)

Module – 3

Energy auditing: Introduction, Elements of energy audits, different types of audit, energy use profiles, measurements in energy audits, presentation of energy audit results.

(8 Hours)

Module – 4

Electricity vis-a-vis Other Commodities: Distinguishing features of electricity as a commodity, Four pillars of market design: Imbalance, Scheduling and Dispatch, Congestion Management, Ancillary Services. Framework of Indian power sector and introduction to the availability-based tariff (ABT).

(8 Hours)

Module – 5

Energy Audit Applied to Buildings: Energy-Saving Measures in New Buildings, Water Audit, Method of Audit, General Energy-Savings Tips Applicable to New as well as Existing Buildings.
Demand side Management: Scope of DSM, Evolution of DSM concept, DSM planning and Implementation, Load management as a DSM strategy, Applications of Load Control, End use energy conservation, Tariff options for DSM.

(8 Hours)

Course Outcomes: At the end of the course the student will be able to

CO1: Understand energy scenario and policy, significance, global energy issues.

CO2: Discuss load management techniques and energy efficiency, demand side management and energy conservation

CO3: Understand the need of energy audit, energy audit methodology and various pillars of electricity market design. Conduct energy audit of electrical systems and buildings

Textbooks:

1. Energy Management Handbook W.C. Turner Publisher John Wiley and Sons.
2. Energy Efficient Electric Motors and Applications H.E. Jordan Plenum Pub. Corp.
3. Energy Management Author Publisher W. R. Murphy, G. Mckay Butterworths

References:

1. Energy Science Principles, Technologies and Impact J. Andrews, N. Jelley Oxford University Press.
2. Market operations in power systems: Forecasting, Scheduling, and Risk Management Shahedepour M.,Yamin H., Zuyi Li. John Wiely & Sons, New York.
3. Energy Conservation Diwan, P. Pentagon Press (2008).

B.E ELECTRICAL AND ELECTRONICS ENGINEERING

Choice Based Credit System (CBCS)

SEMESTER - VI

Electrical and Electronics Measurements (3:0:0) 3

(Open Elective -Group 1)

(Effective from the academic year 2021-22)

Course Code	21EE653	CIE Marks	50
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	50
Total Number of Contact Hours	40	Exam Hours	3

Course objectives:

This course will enable students to:

1. Understand various types of bridges and apply them for the measurement of resistance, inductance and capacitances.
2. Understand about potentiometers and extending instrument ranges
3. Understand various meters working principles, construction and operation, characteristics for the measurement of power, energy, power factor and frequency
4. Understand about various types digital instruments and CROs working principles, construction and operation and characteristics for the measurement of different electrical quantities
5. Understand about working principles, construction, operation and characteristics of Signal Generators, display and recording devices

Module – 1

Measurement of Resistance: Wheatstone's bridge, sensitivity, limitations. Kelvin's double bridge. Earth resistance measurement by fall of potential method and by using Megger.

Measurement of Inductance and Capacitance: Sources and detectors, Maxwell's inductance and capacitance bridge, Anderson's bridge, Desauty's bridge, Schering bridge. Problems. (8 Hours)

Module – 2

Measurement of Power, Energy, Power Factor and Frequency: Torque expression, Errors and minimization, UPF and LPF wattmeters. Measurement of real and reactive power in 3 phase circuits. Errors, adjustments and calibration of single and three phase energy meters, Problems. Construction and operation of single-phase and three phase dynamometer type power factor meter. Weston frequency meter and phase sequence indicator.

(8 Hours)

Module – 3

Extension of Instrument Ranges: Desirable features of ammeters and voltmeters. Shunts and multipliers. Construction and theory of instrument transformers, Desirable characterises, Errors of CT and PT. Turns compensation, Illustrative examples, Silsbee's method of testing CT.

Magnetic measurements: Introduction, measurement of flux/ flux density, magnetising force and leakage factor. (8 Hours)

Module – 4

Electronic and Digital Instruments: Introduction. Essentials of electronic instruments, Advantages of electronic instruments. True rms reading voltmeter. Electronic multimeters. Digital voltmeters (DVM) – Ramp type DVM, Integrating type DVM and Successive - approximation DVM. Q meter. Principle of working of electronic energy meter. (8 hours)

Module – 5

Display Devices: Introduction, character formats, segment displays, Dot matrix displays, Bar graph displays. Cathode ray tubes, Light emitting diodes, Liquid crystal displays, Nixes, Incandescent, Fluorescent, Liquid vapour and Visual displays.

Recording Devices: Introduction, Strip chart recorders, Galvanometer recorders, Null balance recorders, Bridge type recorders, LVDT type recorders, Circular chart and recorders. Digital tape recording, Ultraviolet recorders. Electro Cardio Graph (ECG).

(8 Hours)

Course outcomes:

The students will be able to

CO1: Measure resistance, inductance and capacitance using bridges and determine earth resistance.

CO2: Explain the working of various meters used for measurement of Power, Energy & understand the adjustments, calibration & errors in energy meters.

CO3: Understand methods of extending the range of instruments & instrument transformers.

CO4: Explain the working of different electronic instruments, display and recording devices.

Textbooks:

1. A. K. Sawhney, Electrical and Electronic Measurements and Instrumentation, Dhanpatrai and Sons, New Delhi.
2. Cooper D. and A.D. Heifrick, Modern Electronic Instrumentation and Measuring Techniques, PHI, 2009 Edition
3. H. S. Kalsi, Electronic Instrumentation, Tata Mcgrawhill, 3rd Edition, 2011

References:

1. David A. Bell, Electronic Instrumentation and Measurement, oxford Publication, 2nd Edition, 2009
2. Golding and Widdies, Electrical Measurements and Measuring Instruments, Pitman
3. G. K. Banerjee, Electrical and Electronic Measurements, PHI Learning Pvt. Ltd., 2ndEdition, 2016

B.E. ELECTRICAL AND ELECTRONICS ENGINEERING

Choice Based Credit System (CBCS)

SEMESTER - VI

ELECTRIC VEHICLE TECHNOLOGY (3:0:0)

(Open Elective -Group 1)

(Effective from the academic year 2021 -2022)

Course Code	21EE654	CIE Marks	50
Teaching Hours/Week (L: T:P)	3	SEE Marks	50
Total Number of Lecture Hours	40	Exam Hours	3

Course objectives:

This course will enable students to:

1. To Understand the fundamental laws and vehicle mechanics.
2. To Understand working of Electric Vehicles and recent trends.
3. Ability to analyze different power converter topology used for electric vehicle application.
4. Ability to develop the electric propulsion unit and its control for application of electric vehicles.

Module – 1

Vehicle Mechanics: Roadway Fundamentals, Laws of Motion, Vehicle Kinetics, Dynamics of Vehicle Motion, Propulsion Power, Force-Velocity Characteristics, Maximum Gradability, Velocity and Acceleration, Constant FTR, Level Road, Velocity Profile, Distance Traversed, Tractive Power, Energy Required, Nonconstant FTR, General Acceleration, Propulsion System Design. (8 Hours)

Module – 2

Electric and Hybrid Electric Vehicles: Configuration of Electric Vehicles, Performance of Electric Vehicles, Traction motor characteristics, Tractive effort and Transmission requirement, Vehicle performance, Tractive effort in normal driving, Energy consumption Concept of Hybrid Electric Drive Trains, Architecture of Hybrid Electric Drive Trains, Series Hybrid Electric Drive Trains, Parallel hybrid electric drive trains. (8 Hours)

Module – 3

Energy storage for EV and HEV: Energy storage requirements, Battery parameters, Types of Batteries, Modelling of Battery, Fuel Cell basic principle and operation, Types of Fuel Cells, PEMFC and its operation, Modelling of PEMFC, Supercapacitors**.** (8 Hours)

Module – 4

Electric Propulsion: EV consideration, DC motor drives and speed control, Induction motor drives, Permanent Magnet Motor Drives, Switch Reluctance Motor Drive for Electric Vehicles, Configuration and control of Drives. (8 Hours)

Module – 5

Design of Electric and Hybrid Electric Vehicles: Series Hybrid Electric Drive Train Design: Operating patterns, control strategies, Sizing of major components, power rating of traction motor, power rating of engine/generator, design of PPS Parallel Hybrid Electric Drive Train Design: Control strategies of parallel hybrid drive train, design of engine power capacity, design of electric motor drive capacity, transmission design, energy storage design.

(8 Hours)

Course outcomes:

The students will be able to:

CO1: Explain the roadway fundamentals, laws of motion, vehicle mechanics and propulsion system design.
CO2: Explain the working of electric vehicles and hybrid electric vehicles in recent trends.
CO3: Model batteries, Fuel cells, PEMFC and super capacitors.
CO4: Analyze DC and AC drive topologies used for electric vehicle application.
CO5: Develop the electric propulsion unit and its control for application of electric vehicles

Textbooks

1. M. Ehsani, Y. Gao, S. Gay and Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals", CRC Press, 2005.
2. Iqbal Husain, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2003.

References:

1. Sheldon S. Williamson, "Energy Management Strategies for Electric and Plug-in Hybrid Electric", Springer, 2013.
2. C.C. Chan and K.T. Chau, "Modern Electric Vehicle Technology", Oxford University, 2001.
3. Chris Mi, M. Abul, Masrur, David Wenzhong Gao, "Hybrid Electric Vehicles Principles and Applications with Practical Perspectives", Wiley Publication, 2011.

B.E ELECTRICAL AND ELECTRONICS ENGINEERING

Choice Based Credit System (CBCS)

SEMESTER - VI

CONTROL SYSTEMS (4:0:0) 4

(Effective from the academic year 2020 -2021)

Course Code	21EE67	CIE Marks	50
Teaching Hours/Week (L: T:P)	4:0:0	SEE Marks	50
Total Number of Lecture Hours	50	Exam Hours	3

Course objectives:

This course will enable students to:

1. Construct mathematical models of electrical, mechanical, and electro-mechanical systems.
2. Apply signal flow graph techniques and block reduction techniques to find the transfer function.
3. Find the different time and frequency domain indices.
4. Construct root locus, bode, and Nyquist plots
5. Analyze the stability of a given linear time-invariant system.

Module – 1

a. Introduction: Role of the control system in health and safety aspects of human lives. Applications of Control systems in system and process automation.
Examples of open loop and closed loop Systems.

b.Mathematical Modeling of Linear Systems: Modeling of mechanical system elements, electrical systems, transfer functions of single input and single output systems, Analogous Systems, Obtaining transfer function of Servo Motors, Lag & Lead Compensators.

(10 Hours)

Module – 2

a. Block Diagram Reduction Technique: Introduction to block diagram, Block diagram of a closed loop system, the procedure for drawing block diagram, and block diagram reduction rules. Simple problems.

b. Signal Flow Graphs: Introduction to signal flow graph. Construction of signal flow graphs, basic properties of a signal flow graph, signal flow graph algebra, construction of signal flow graph for control systems. Problems

(10 Hours)

Module – 3

a. Time response analysis: Time response specifications, the unit step response of first order, second order systems, derivation of time response specifications (Rise time, Peak time, Maximum overshoot, settling time). Steady-state error, and error constants. Concept of dominant poles.

b. Stability Analysis: Concept of stability, Hurwitz criteria, Routh-Hurwitz criterion, Specual cases of Routh-Hurwitz criteria, applications of RH criterion with limitations.

(10 Hours)

Module – 4

a. Root locus technique: Introduction to root locus concepts, Construction rules, and stability analysis from root locus plot. Simple problems (The order of the characteristic equation is limited to 3rd order only)

b. Frequency Domain Analysis: Bode plots: Frequency domain specifications. Bode plots of basic factors, Gain Margin and Phase Margin (only definition), Relative stability. Bode plot problems. Determination of gain and phase margin using bode plots.

(10 Hours)

Module – 5

a. Nyquist plot: Statement of Nyquist stability criterion, Stability Analysis using Nyquist plot. Simple Problems.

b. Compensators and controllers:

Compensators: Simple design problems on Phase-Lead Controller, Design with Phase-Lag Controller. Design with phase lead-lag controller

Controllers: Study the effect of P, PI, PD and PID controllers (qualitative discussion limited to block diagram level only)

Self-Learning: Study the effect of controllers and compensators using Mat-Lab

(10 Hours)

Course outcomes:

The students will be able to:

CO1: Obtain the transfer function of a linear time-invariant system.
CO2: Determine transient and steady-state time response.
CO3: Apply the block diagram and signal flow graph technique to find the transfer function.
CO4: Analyze the stability of LTI systems in the time/frequency domain using different techniques.
CO5: Apply a modern tool (ex. Mat-Lab) to analyze control problems.

Textbooks:

1. Nagrath & Gopal, "Control Systems Engineering", New Age International Publishers, 6th Edition, 2018
2. A. Anand Kumar, "Control Systems", PHI Learning Private Limited, 2nd Edition, 2014

References:

1. Norman S. Nise, "Engineering control systems", Wiley India Edition, 2018
2. Richard C Dorfetal, "Modern Control Systems", Pearson 11th Edition, 2008.

B.E ELECTRICAL AND ELECTRONICS ENGINEERING

Choice Based Credit System (CBCS)

SEMESTER – VI

Power System Analysis (3:0:0) 3

(Effective from the academic year 2021-22)

Course Code	21EE68	CIE Marks	50
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	50
Total Number of Contact Hours	40	Exam Hours	3

Course Objectives:

This course will enable students to:

1. To introduce the per unit system and explain its advantages and computation.
2. To explain the concept of one line diagram and its implementation in problems.
3. To explain the necessity and conduction of short circuit analysis.
4. To explain analysis of three phase symmetrical faults on synchronous machine and simple power systems.
5. To discuss selection of circuit breaker.
6. To explain symmetrical components, their advantages and the calculation of symmetrical components of voltages and currents in un-balanced three phase circuits.
7. To explain the concept of sequence impedance and its analysis in three phase unbalanced circuits.
8. To explain the concept of sequence networks and sequence impedances of an unloaded synchronous generator, transformers and transmission lines.
9. To explain the analysis of synchronous machine and simple power systems for different unsymmetrical faults using symmetrical components.
10. To discuss the dynamics of synchronous machine and derive the power angle equation for a synchronous machine.
11. Discuss stability and types of stability for a power system and the equal area criterion for the evaluation of stability of a simple system.

Module – 1

Representation of Power System Components: Introduction, Single-phase Representation of Balanced Three Phase Networks, One-Line Diagram and Impedance or Reactance Diagram, Per Unit (PU)System, Steady State Model of Synchronous Machine, Power Transformer, Transmission of Electrical Power, Representation of Loads. (8Hours)

Module – 2

Symmetrical Fault Analysis: Introduction, Transient on a Transmission Line, Short Circuit of a Synchronous Machine(On No Load), Short Circuit of a Loaded Synchronous Machine, Illustrative simple examples on power systems. Selection of Circuit Breakers. (8 Hours)

Module – 3

Symmetrical Components: Introduction, Symmetrical Component Transformation, Phase Shift in Star-Delta Transformers, Sequence Impedances of Transmission Lines, Sequence Impedances and Sequence Network of Power System, Sequence Impedances and Networks of Synchronous Machine, Sequence Impedances of Transmission Lines, Sequence Impedances and Networks of Transformers, Construction of Sequence Networks of a Power System. (8 Hours)

Module – 4

Unsymmetrical Fault Analysis: Introduction, Symmetrical Component Analysis of Unsymmetrical Faults, Single Line-To-Ground (LG) Fault, Line-To-Line (LL) Fault, Double Line-To-Ground (LLG) Fault, Open Conductor Faults. (8 Hours)

Module – 5

Power System Stability: Introduction, Dynamics of a Synchronous Machine, Review of Power Angle Equation, Simple Systems, Steady State Stability, Transient Stability, Equal Area Criterion, Factors Affecting Transient Stability, Multi machine stability studies, classical representation. (8 Hours)

Course Outcomes: The students will be able to:

CO1: Model the power system components & construct per unit impedance diagram of power system.
CO2: Analyze three phase symmetrical faults on power system.
CO3: Compute unbalanced phasors in terms of sequence components and vice versa, also develop sequence networks
CO4: Analyze various unsymmetrical faults on power system.
CO5: Examine dynamics of synchronous machine and determine the power system

Textbooks:

1.Elements of Power System William D. StevensonJr McGraw Hill 4th Edition, 1982
2. Modern Power System D. P. Kothari McGraw Hill 4th Edition, 2011

References:

1. Power System Analysis and Design J.Duncan Glover et al Cengage 4th Edition, 2008
2. Power System Analysis Hadi Sadat McGraw Hill 1st Edition, 2002

B.E ELECTRICAL AND ELECTRONICS ENGINEERING

Choice Based Credit System (CBCS)

SEMESTER - VI

CONTROL SYSTEMS LAB (0:0:1) 1

(Effective from the academic year 2021-22)

Course Code	21EEL69A	CIE Marks	50
Teaching Hours/Week (L: T:P)	0:0:3	SEE Marks	50
Total Number of Contact Hours	40	Exam Hours	3

Course Objectives:

This course will enable students to:

1. Determine the Transfer function of Linear Time Invariant systems
2. Analyze the Transient and steady state performance of a system
3. Apply graphical techniques to perform the stability analysis
4. Appreciate the effect of compensators and controllers

LIST OF EXPERIMENTS

1. Experiment to draw the speed torque characteristics of AC servo motor / DC servo motor
2. Experiment to draw synchro pair characteristics.
3. Experiment to determine frequency response of a second order system.
4. To design a passive RC lead compensating network for the given specifications, viz, the maximum phase lead and the frequency at which it occurs and to obtain the frequency response.
5. To design a passive RC lag compensating network for the given specifications, viz, the maximum phase lag and the frequency at which it occurs and to obtain the frequency response.

Experiments 6 to 10 must be done using MATLAB/SCILAB only.

6. To simulate and draw the frequency response characteristics of the lag – lead compensator network and determination of its transfer function.
7. (a) To simulate a typical second order system and determine step response and evaluate time response specifications.
   (b) To evaluate the effect of additional poles and zeros on time response of second order system.
   (c) To evaluate the effect of pole location on stability.
8. To simulate a second order system and study the effect of (a) P, (b) PI, (c) PD and (d) PID controller on the step response.
9. To simulate a D.C. Position control system and obtain its step response.
10. To study the stability analysis of given control system using a) root locus, b) bode plots

Open ended experiments

1. Study the effect of different slandered inputs on the steady state error for given i) Type-0 ii) Type-1 iii) Type-2.
2. Evaluate the stability of given system using RH criterion

Course outcomes:

The students will be able to:

After the successful completion of the course, the student will be able to

1. Execute time response analysis of a second order control system using MATLAB
2. Analyze and interpret stability of the system through Root Locus, Bode plot and Nyquist plot.
3. Design Lag, Lead, Lead-Lag compensators and verify experimental results using MATLAB.
4. Analyze toque- speed characteristics of DC and AC servomotors.
5. Analyze the effect of P, PI, PD and PID controllers on a control system.

B.E ELECTRICAL AND ELECTRONICS ENGINEERING

Choice Based Credit System (CBCS)

SEMESTER - VI

COMPUTER AIDED ELECTRICAL DRAWING (0:0:1) 1

(Effective from the academic year 2021 -2022)

Course Code	21EEL69B	CIE Marks	50
Teaching Hours/Week (L: T:P)	0:1:2	SEE Marks	50
Total Number of Lecture Hours	40	Exam Hours	3

Course objectives:

This course will enable students to:

1. Explain the terminology of DC and AC armature windings.
2. Explain the design and procedure to draw armature winding diagrams for DC and AC machines.
3. Explain the substation equipment, their location in a substation and development of a layout for substation.
4. Explain different sectional views of transformers, DC & AC machines and its parts using the design data.

Module – 1

Introduction: Application of CAD tool in development of engineering drawing.

Winding Diagrams:

(a) Developed Winding Diagrams of D.C. Machines: Simplex and Duplex Double Layer Lap and Wave Windings.

(b) Developed Winding Diagrams of A.C. Machines: Integral and Fractional Slot Double Layer Three Phase Lap and Wave Windings.

Module – 2

Single Line Diagrams: Single Line Diagrams of Generating Stations and Substations Covering Incoming Circuits, Outgoing Circuits, Bus bar Arrangements (Single, Sectionalized Single, Main and Transfer, Double Bus Double Breaker, Sectionalized Double Bus, One and a Half Circuit Breaker Arrangement, Ring Main), Power Transformers, Circuit Breakers, Isolators, Earthing Switches, Instrument Transformers, Surge or Lightning Arresters, Communication Devices (Power - Line Carrier) and Line Trap.

Module – 3

Electrical Machine Assembly Drawings Using Design Data, Sketches or Both:

Transformers - Sectional Views Of Single And Three Phase Core And Shell Type Transformers.

Electrical Machine Assembly Drawings Using Design Data, Sketches or Both:

D.C. Machine - Sectional Views of Yoke with Poles, Armature and Commutator dealt separately.

Electrical Machine Assembly Drawings Using Design Data, Sketches or Both:

Alternator – Sectional Views of Stator and Rotor dealt separately.

Summary: Recap of Electrical drawing fundamentals.

Course outcomes:

The students will be able to:

CO1: Analyse and Draw the single line diagram sketches by using Auto CAD software

CO2: Analyse the design data given and draw winding diagrams of D.C & A.C Machines by using Auto CAD software.

CO3: Analyse the design data given and draw the sectional views of electrical machines by using Auto CAD software.

Question paper pattern:

1. The question paper will have two parts, PART – A and PART – B.
2. Each part is for 50 marks.

Part A is for Modules 1 and 2.

1. Questions 1 and 2 of PART - A will be only on DC windings or on AC windings. Students have to answer any one of them. The marks prescribed is 30.
2. Question 3 of PART – A covering module 2 is compulsory. The marks prescribed is 20.

Part B is for Modules 3.

1. Questions 4 and 5 of PART – B will cover any two any two topics of modules 3. Students have to answer any one of them. The marks prescribed is 50.

Textbooks

1. A.K.Sawhney, "A course in Electrical Machine", DhanpatRai, 6th Edition, 2013.

References

1. K. L. Narang, "Electrical Engineering Drawing", SatyaPrakashan, 2014.